Abstract

Objectives. This narrative review examines the current status of evidence-based practice and knowledge translation in diagnostic radiography. It explores knowledge translation efforts in the allied health professions aimed at systematically implementing evidence-based practice and suggests ways that these may be applied within diagnostic radiography.

Key findings. Knowledge translation in diagnostic radiography is in its infancy with numerous examples of key findings of rigorous studies not implemented in practice. Utilising frameworks, models and theories to systematically translate knowledge into evidence-based practice has been shown to be effective in other allied health professions. Whilst few studies in diagnostic radiography report utilising these systematic approaches to implementing evidence-based practice, those that do, show promising results. Attitudes towards evidence-based practice within diagnostic radiography are becoming more positive and it is important to use this positive shift in attitudes to create real evidence-based change in the profession.

Conclusion. The potential benefits of systematically translating knowledge into evidence-based practice in diagnostic radiography are wide reaching with positive implications for our patients, the profession and wider community. Leaders at all levels of radiography must work towards implementing evidence-based practice in their daily work.

Implications for practice. Systematic approaches to knowledge translation should be adopted and reported in diagnostic radiography in order to more effectively translate knowledge into evidence-based practice.

Keywords

Evidence-based practice; evidence-based radiography; knowledge translation; implementation science; diagnostic radiographer

Introduction

Within healthcare there is a known gap between the best available evidence and clinical practice. [1,2] Where the highest forms of evidence should guide best practice, legacy practices often persist. Translating this evidence or knowledge into practice is called knowledge translation (KT). KT seeks to "address the gap between what is known from research and knowledge synthesis and implementation of this knowledge by key stakeholders with the intention of improving health outcomes and efficiencies of the health care system". [3] Changing clinicians' behaviour can be challenging but whilst the barriers to implementing best practice are well researched in disciplines such as medicine and nursing [4,5] less research exists specific to diagnostic radiography (DR).

Evidence-based practice (EBP) is a fundamental cornerstone of modern healthcare. Its importance has been enshrined in radiographer codes of practice internationally. [6,7] Evidence-based radiography (EBR) has been defined as "radiography informed and based on the combination of clinical expertise and the best available research-based evidence, patient preferences and available resources."[8] The aim of both EBP and EBR is to provide the best possible outcomes for patients. Within allied health professions, attitudes to EBP tend to be positive, however insufficient time and underdeveloped skills appear to hinder KT efforts. [9,10] Radiographers self-report lower levels of the skills that are required for EBP (i.e., research and information technology skills, critical analysis, and the ability to apply evidence in context), compared with other allied health disciplines and tend not to spend much time engaging with published literature.[9,11] When compared to medicine, nursing, and some other allied health professions, radiography has required University degree level qualification for a short period of time, with this level of education only becoming commonplace in the 1990's. These factors may contribute to why the research that is produced within DR is often slow to be translated into practice, with recent studies showing that EBR is not widely implemented. [11] Conducting research and translating it into practice is an important professional responsibility [8,12,13] as this translation has positive effects on a wide range of parties, especially our patients.

We know from other healthcare disciplines that KT, in order to create evidence-based change, is a slow process that requires meticulous planning and implementation. [14] This literature review will compare KT in DR to KT in other disciplines in order to identify potential ways in which to better translate knowledge to practice in DR. It will do this by first examining the current state of EBR, then by providing specific examples of the knowledge to practice gap within radiography, and finally exploring KT strategies that are being used effectively in other health professions to illustrate how these could apply within DR.

Methods

This narrative literature review examines literature about EBP in DR from earliest records until 2020. A narrative approach was selected due to its ability to broadly and comprehensively "describe the history or development of a problem or its management". [15] The authors adopted a cyclical, iterative search approach, and sought the advice of a librarian to develop the search strategy and select databases. Medline and CINAHL databases were searched using keywords (see Table 1). After the first stage (database search) was completed, a second stage ('snowball' search) began. Starting with the existing journal articles, the authors checked the reference list and citing articles to identify any additional articles that may have been omitted from the first stage of the search.

Table 1 approximately here

Background

Evidence-based radiography

It is acknowledged that EBR has not well practiced and that a substantial knowledge to practice gap exists. [8,16] In 2006, a sample of 70 radiographers in the United Kingdom were surveyed about their knowledge and use of EBP; 68.6% of those surveyed rated their knowledge of clinical effectiveness and evidence-based practice as low. [9] These attitudes are slowly beginning to change with a more recent survey of 83 Ugandan radiographers utilising the same survey tool showing that this level decreased; with only 43% of respondents rating themselves as low. [17] Whilst the second survey, indicates fewer radiographers perceived 'low' levels of EBP knowledge, this clearly remains a concern for almost half the respondents. Radiographers are known to have a tendency to rely on their clinical expertise and protocols rather than justify their decisions using current research evidence [16] and report being more willing to act on advice from a colleague than from a journal article. [9] There is a perception amongst radiographers that their ability to change current practice is limited and that a greater incentive is required in order for change to occur. [10] Even when departmental protocols are evidence-based, radiographers have a tendency to apply practices learned during their training, even if these may be outdated, rather than follow departmental protocols. [18]

A significant problem arises when best practice changes over time and the training that radiographers received is no longer current. For example, the recent position statement of the American Association of Physicists in Medicine (AAPM) on the Use of Patient Gonadal and Fetal Shielding is well researched and based in current evidence. [19] However, the position statement has created dissent among the radiographic community and a survey of the Advanced Health Education Centre's readership indicated that 86% of radiographers would continue to shield their patients even if their department adopted a no shielding policy. [20] While professional bodies representing radiologists [21] and medical physicists [22] have been quick to adopt the position statement, those representing radiographers such as the American Society of Radiologic Technologists, have "heard from several members and facilities that do not agree with the recommendation" [23] and as such have decided not to adopt the recommendations at this time. Despite evidence that shielding their patients may be more harmful than beneficial, [24,25] some radiographers choose not to implement the evidence-based recommendation and continue with their legacy practice.

Despite some resistance, there is evidence that attitudes to EBR and research within DR are changing. Although historically radiographers have not considered research a necessary element of their professional career, [26] more recent studies have shown emerging positive attitudes, the following three studies were included as exemplars of recent reflections of international views within radiography in relation to EBP. A total of 63% of surveyed Norwegian radiographers agreed that radiography related research is important and that radiographers should take a leading position. [27] A 2013 study of radiographers in Ghana indicated that 60% were interested in undertaking research. [28] Furthermore, 84% of surveyed Singaporean radiographers agreed that conducting research would be beneficial to their department. [29] Radiographers who participate in research related activities are more likely to implement EBP and have a research-oriented way of working.

Potential explanations for some changes in attitude are the transition of radiography to a degree level qualification, the professionalisation of radiography and role advancement for radiographers. [30] Internationally there has been a strong push towards the professionalisation of DR. [13] There has been a historical tendency in DR to rely heavily on input and advice from other professions such as radiologists, medical engineers, and physicists, as research relating to the practice of diagnostic radiographers tends to come from these professions. However, with greater professional standing comes greater responsibility and there is a need for radiographers to have a more substantial input into the evidence base for the profession. [13,31]

Systematic approaches to knowledge translation in health

Approaching KT in a systematic way has proven advantageous in other healthcare professions, leading to the promotion and use of numerous frameworks, models, and theories. [32-35] Systematic approaches aim to inform KT efforts in order to help ensure the best possible likelihood of successful implementation. Many systematic approaches exist; including for example, the Promoting Action on Research Implementation in Health (PARiHS) Framework, Practical Application of Clinical Evidence System (PACES), and the Theoretical Domains Framework (TDF), and each has been used in different contexts to guide, understand, or evaluate implementation. [36-38] Scott et al. explored the advantages of systematic approaches, explaining that they may "inform the development and delivery of interventions; guide evaluation; explore moderating factors and causal mechanisms; and facilitate a better understanding of the generalizability and replicability of implementation interventions."[34]

There is a plethora of evidence from the discipline of implementation science that suggests that systematic approaches to KT are effective at both improving clinician knowledge and changing clinician behaviour. [33,35,39,40] A recent systematic review identified 49 different KT models, frameworks and theories, varying in their applicability and validity. [41] However, the reasoning behind why a particular KT approach was selected and applied is often not reported. [34,42] The overwhelming number of theories can create a challenge at the clinical level when choosing the most appropriate method of implementing an evidence-based change. [14] In response to this, Nilsen proposed a taxonomy, (see Figure 1), for these models based on the aim of the change agent. [14] Clinicians may select their desired outcome, whether that be guiding translation, understanding influencing factors or evaluating an implementation attempt that has already taken place. The taxonomy then guides the clinician to the most appropriate type of framework, model or theory.

Figure 1 approximately here.

Strategies that are multi-faceted and active in their nature are the most effective in creating a desired change. [34,35] A systematic review of KT interventions in allied health found that although education is one of the most common interventions used to create change, when it is used in isolation, it has a limited impact. [34] Close examination of the barriers to change and carefully planned strategies to overcome those barriers is key to a successful translation. [1,43] It is important to note that the nature of barriers and facilitators of change are dynamic and interrelated and this nature must be considered when planning strategies. [44]

Discussion

The knowledge to practice gap in radiography

A complex professional culture exists within radiography where medical dominance and protectionism are prevalent. [45] This includes a deferral to radiologists in decision-making and a tendency to cede to referral patterns even when radiographers judge that a particular imaging test may not be appropriate. Bairstow et al. found that '56% of patients had evidence of inappropriate diagnostic practice'[46] and a 2016 study examining justification of CT and MRI showed that 6.54% of examinations were either unjustified or had questionable justification. [47]

An example of this is the prevalence of unjustified abdominal x-rays on patients presenting with acute abdominal pain in line with the Royal College of Radiologists guidelines. [48-52] Whilst radiographers attribute this to medical dominance, it is a professional requirement for radiographers to justify examinations. Despite this requirement, the application of justification of examinations in practice remains inconsistent among radiographers, meaning that up to 56% of examinations are inappropriate and are carried out to the possible detriment of patients. [53]

An example of the knowledge to practice gap in radiography that could be easily implemented by radiographers with arguably minimal external issues is an adaption of the technique utilised during radiography of the clavicle as examined by McEntee and Kinsella. [18] This study demonstrated statistically significant reductions in organ radiation dose to the eyes and breast as well as increased image quality when utilising a postero-anterior (PA) as opposed to an antero-posterior (AP) projection technique for clavicle imaging as well as demonstrating increased image quality. [18] Despite the known benefits, radiographers have not appeared to implement this into their practice. [18] A possible explanation may be a lack of confidence on the part of radiographers of this unfamiliar positioning technique and the possible associated increased repeat rate. [18] However, given the professional aptitude of radiographers, this barrier should be easily overcome with education and training.

These are just two of the many examples within radiography where a knowledge to practice gap exists. The impact of the underuse of available evidence has broad implications for a wide range of stakeholders. Patients, policymakers, clinicians, educators, and researchers alike stand to benefit from a strong shift towards EBR. If we examine the example of changing technique in radiography of the clavicle, the positive impact is clear; our patients receive significantly reduced doses to highly radiosensitive organs.[54] In the example of unjustified abdominal imaging, the impact of not adhering to known best practice has wider implications than patient dose. The financial benefits in the form of saving unnecessary procedures have impacts at a local level within departments, and on a broader level within the healthcare budget. [51]

Educators aim to equip their students with the necessary skills to become evidence-based practitioners. However, strong social forces mean that students and new graduates quickly adopt the dogma of departments that often self-replicate and reinforce their practices as a result. Higgins, Robinson and Hogg note that "initiating a successful research culture requires clear goals and effective leadership". [55] This requires strong leadership from senior radiographers and managers in order to ensure knowledge translation is supported in the clinical environment. The opportunities

for positive change within the profession of DR are vast. It is therefore important to consider what radiographers may learn from other healthcare disciplines in relation to KT.

Knowledge translation in diagnostic radiography

There is no 'one size fits all' model, framework or theory for translating knowledge into practice within healthcare broadly or indeed within radiography. Different groups within the radiography community need to approach this translation in different ways in order to create the cultural shift required. Utilising Nilsens' taxonomy from Figure 1, [14] it may be most beneficial for heads of departments to focus on guiding the translation process by using process models, for example the Ottawa Model. [56] Professional bodies could focus on exploring the influences of implementation within radiography. A determinant framework such as the revised Theoretical Domains Framework [38] would provide a good starting point. Individual radiographers wishing to ensure that their practice is evidence-based may utilise a simplified model such as Strauss and Sackett's five step framework for applying EBP. [57]

Little evidence currently exists regarding explicit KT strategies within DR. Whilst it is likely that many of the principles discussed above will apply in a DR context this is yet to be examined within the profession. Various authors proposed that utilising the Strauss and Sackett five step framework for applying evidence-based medicine may be useful in DR and some have presented several hypothetical scenarios detailing how this may be applied. [12,54,57,58] This model may be useful on a small scale to individual clinicians looking to improve their own performance, however strategies to help foster KT on a broader scale within departments and the profession will also be required.

A recent example of radiographer-initiated implementation is outlined in a report on premedication for heart rate-controlled CT Coronary Angiography. [37] The authors describe a successful implementation of a premedication protocol using the PACES and Getting Research into Practice (GRiP) audit and feedback tools. A three phase implementation strategy consisting of stakeholder engagement, design and implementation, and follow up audit, was utilised in order to successfully guide and evaluate this implementation. The study achieved a high compliance rate with the change implemented that was in line with evidence-based standards. Similar to many implementation reports from other disciplines, the justification for the use of these particular tools is not discussed in the report. Implementation initiatives within DR need to be reported more consistently and with justification of the model, framework or theory used so that evidence is generated as to which approaches are the most effective.

The way forward for evidence-based radiography

EBR is a professional requirement. How do we enable, encourage and educate radiographers to be evidence-based practitioners? How do we create cultural change that empowers radiographers to assert their knowledge in a context that has long been overshadowed by medical dominance?

Early career radiographers seem to adapt quickly to the dogma of departments, [16] with a recent Australian study finding that allied health professionals' confidence in applying EBP drops in the first five years of clinical practice. [59] This finding reflects a missed opportunity for building EBP within the radiography community. Perhaps fostering a more active and positive research culture within the profession by linking this more strongly with continuing professional development would promote mid-career radiographers' interest levels in research and EBR. By strongly integrating research into

radiographers' formal University training this proactive research culture may be fostered within the profession. [55] Investing additional resources in preparing student radiographers in the application of evidence-based practice may help to change the culture of the profession long-term. Pedagogic interventions that have been suggested for use in radiography education include role modelling from academic staff, service user involvement in preparation for practice, facilitated reflection, and problem-based learning. [8,60,61] Much research is currently being undertaken that examines embedding research into university curriculum. Further research as to how we can better equip students to have the confidence to apply these skills rather than adapting to the status quo of their department once they have graduated and entered practice is required.

Two emergent groups have been shown to have more positive attitudes towards better utilising findings from research into clinical practice. [16] The first group are senior radiographers who have had experience in research related activities. The second group are the new generation of radiographers who typically may have higher level qualifications (bachelors and masters). Supporting senior radiographers to mentor junior colleagues to participate in research and apply EBP is imperative. This can be done by ensuring that departmental protocols are evidenced based, that research activity is embedded into position descriptions for senior and consultant radiographers, by providing additional training and workload recognition for all staff and recognising research and EBR as 'business as usual'.

Changing clinical practice is a slow and complex process that requires careful strategizing, effective leadership, and collaboration across the profession. This process may be facilitated by the use of a systematic approach informed by an appropriate KT model, theory, or framework. As KT is in its infancy within radiography, we can learn from the experiences of other allied health professions, where a systematic approach has proven beneficial.

Conclusion

It is imperative that we conduct further research into the effectiveness of specific KT strategies to create an evidence based for knowledge translation in diagnostic radiography. A significant challenge in the coming years will be ensuring that we have effective leadership that enables and encourages senior radiographers and the newer generation to embed a culture of research and EBR within the profession. Researchers and clinicians must work together to ensure that relevant clinical questions are being investigated using appropriate methods and that recommendations are implemented. Implementing EBR stands to positively affect the profession, our patients, and the broader community. Radiography has a long way to go in terms of implementing evidence-based research into everyday clinical practice, but we must capitalise on the positive attitude shift to create the change within the profession that is so clearly required.

1 Grimshaw, J. M., Eccles, M. P., Lavis, J. N., Hill, S. J. & Squires, J. E. Knowledge translation of research findings. *Implementation Science* **7**, 50, doi:10.1186/1748-5908-7-50 (2012).
2 Grol, R. & Grimshaw, J. From best evidence to best practice: effective implementation of change in patients' care. *The Lancet* **362**, 1225-1230, doi:https://doi.org/10.1016/S0140-6736(03)14546-1 (2003).
3 Graham, I. D. *et al.* Lost in knowledge translation: Time for a map? *Journal of Continuing Education in the Health Professions* **26**, 13-24, doi:10.1002/chp.47 (2006).

4 Brown, C. E., Wickline, M. A., Ecoff, L. & Glaser, D. Nursing practice, knowledge, attitudes and perceived barriers to evidence-based practice at an academic medical center. *Journal of Advanced Nursing* **65**, 371-381, doi:10.1111/j.1365-2648.2008.04878.x (2009).
5 Cabana, M. D. *et al.* Why don't physicians follow clinical practice guidelines? A framework for improvement. *Jama* **282**, 1458-1465, doi:10.1001/jama.282.15.1458 (1999).
6 Technologists, I. S. R. R. T. *Code of Ethics*, <https://www.isrrt.org/code-ethics> (No Date).
7 Australia, M. R. P. B. A. (2014).
8 Hafslund, B., Clare, J., Graverholt, B. & Wammen Nortvedt, M. Evidence-based radiography. *Radiography* **14**, 343-348, doi:10.1016/j.radi.2008.01.003 (2008).
9 Upton, D. & Upton, P. Knowledge and use of evidence-based practice by allied health and health science professionals in the United Kingdom. *Journal of allied health* **35**, 127-133 (2006).
10 Joyce, M. & O'Leary, D. The Increased Source to Image-receptor Distance Technique: What Is Preventing Implementation in Clinical Practice? *Journal of Medical Imaging and Radiation Sciences* **45**, 260-268, doi:https://doi.org/10.1016/j.jmir.2014.04.003 (2014).
11 Abrantes, A. F. C. L. *et al.* Evidence-based radiography: A new methodology or the systematisation of an old practice? *Radiography* **26**, 127-132, doi:https://doi.org/10.1016/j.radi.2019.09.010 (2020).
12 Murphy, C. N. & Sharp, R. L. Evidence-based Practice for Medical Radiation Technologists. *Journal of Medical Imaging and Radiation Sciences* **40**, 148-154, doi:https://doi.org/10.1016/j.jmir.2009.09.006 (2009).
13 Sim, J. & Radloff, A. Profession and professionalisation in medical radiation science as an emergent profession. *Radiography* **15**, 203-208, doi:https://doi.org/10.1016/j.radi.2008.05.001 (2009).
14 Nilsen, P. Making sense of implementation theories, models and frameworks. *Implementation Science* **10**, 53, doi:10.1186/s13012-015-0242-0 (2015).
15 Green, B. N., Johnson, C. D. & Adams, A. Writing narrative literature reviews for peer-reviewed journals: secrets of the trade. *Journal of Chiropractic Medicine* **5**, 101-117, doi:https://doi.org/10.1016/S0899-3467(07)60142-6 (2006).
16 Ahonen, S.-M. & Liikanen, E. Radiographers' preconditions for evidence-based radiography. *Radiography* **16**, 217-222, doi:10.1016/j.radi.2010.01.005 (2010).
17 Nalweyiso, D. I., Kabanda, J., Mubuuke, A. G., Sanderson, K. & Nnyanzi, L. A. Knowledge, attitudes and practices towards evidence based practice: A survey amongst radiographers. *Radiography* **25**, 327-332, doi:https://doi.org/10.1016/j.radi.2019.03.004 (2019).
18 McEntee, M. F. & Kinsella, C. An examination of practice during radiography of the clavicle. *Radiography* **16**, 125-130, doi:https://doi.org/10.1016/j.radi.2009.12.002 (2010).
19 Medicine, A. A. o. P. i. *AAPM Position Statement on the Use of Patient Gonadal and Fetal Shielding*, <https://www.aapm.org/org/policies/details.asp?id=468&type=PP> (2019).
20 Online, A. H. E. *What Would You Do? Stop Shielding Your Patients?*, <https://aheconline.blog/2018/01/15/what-would-you-do-stop-shielding-your-patients/> (2018).
21 Radiology, A. C. R. *ACR endorses AAPM position on patient gonadal and fetal shielding*, <https://www.imagewisely.org/News/General/ACR-endorses-the-AAPM-position-on-patient-gonadal-and-fetal-shielding> (2019).
22 Physicists, C. O. M. P. *COMP endorses AAPM position statement on the use of patient gonadal and fetal shielding*, <https://www.comp-ocpm.ca/english/news/comp-endorses-aapm-position-statement-on-the-use-of-patient-gonadal-and-fetal-shielding.htm> (2019).
23 Technologists, A. S. o. R. ASRT Board of Directors Provides Update on Gonadal and Fetal Shielding Position. (2019).
24 Frantzen, M. J. *et al.* Gonad shielding in paediatric pelvic radiography: disadvantages prevail over benefit. *Insights into imaging* **3**, 23-32, doi:10.1007/s13244-011-0130-3 (2012).
25 Lee, M. C., Lloyd, J. & Solomito, M. J. Poor Utility of Gonadal Shielding for Pediatric Pelvic Radiographs. *Orthopedics* **40**, e623-e627, doi:10.3928/01477447-20170418-03 (2017).

26 Challen, V., Kaminski, S. & Harris, P. Research-mindedness in the radiography profession. *Radiography* **2**, 139-151, doi:10.1016/S1078-8174(96)90005-X (1996).
27 Vikestad, K. G., Hafskjold, L., Kjelle, E., Sebuodegard, S. & Hofvind, S. Radiographers' opinions on radiography research in Norway - A national survey. *Radiography (London, England : 1995)* **23**, 135-140, doi:10.1016/j.radi.2016.12.006 (2017).
28 Botwe, B. Research engagement and attitudes of Ghanaian radiographers. *World Journal of Medicine and Medical Science* **1**, 128-135 (2013).
29 Ooi, C.-C., Lee, S. H.-E. & Soh, B. P. A survey on the research awareness and readiness among radiographers in Singapore General Hospital (SGH). *Radiography* **18**, 264-269, doi:https://doi.org/10.1016/j.radi.2012.06.004 (2012).
30 Malamateniou, C. Radiography and research: A United Kingdom perspective. *European Journal of Radiography* **1**, 2-6, doi:https://doi.org/10.1016/j.ejradi.2008.12.003 (2009).
31 Smith, T. & Lewis, S. Opportunities for role development for medical imaging practitioners in Australia: part 1 - rationale and potential. *Radiographer: The Official Journal of the Australian Institute of Radiography, The* **49**, 161-165 (2002).
32 Grimshaw, J. M. *et al.* Effectiveness and efficiency of guideline dissemination and implementation strategies. *Health technology assessment (Winchester, England)* **8**, iii-iv, 1-72 (2004).
33 Menon, A., Korner-Bitensky, N., Kastner, M., McKibbon, K. A. & Straus, S. Strategies for rehabilitation professionals to move evidence-based knowledge into practice: a systematic review. *Journal of rehabilitation medicine* **41**, 1024-1032, doi:10.2340/16501977-0451 (2009).
34 Scott, S. D. *et al.* Systematic review of knowledge translation strategies in the allied health professions. *Implementation Science* **7**, 70, doi:10.1186/1748-5908-7-70 (2012).
35 Bero, L. A. *et al.* Closing the gap between research and practice: an overview of systematic reviews of interventions to promote the implementation of research findings. The Cochrane Effective Practice and Organization of Care Review Group. *BMJ (Clinical research ed.)* **317**, 465-468, doi:10.1136/bmj.317.7156.465 (1998).
36 Kitson, A. L. *et al.* Evaluating the successful implementation of evidence into practice using the PARiHS framework: theoretical and practical challenges. *Implementation science : IS* **3**, 1, doi:10.1186/1748-5908-3-1 (2008).
37 Mander, G. T. W. Computed tomography coronary angiography with heart rate control premedication: a best practice implementation project. *JBI database of systematic reviews and implementation reports* **15**, 1968-1976, doi:10.11124/jbisrir-2016-003270 (2017).
38 Cane, J., O'Connor, D. & Michie, S. Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implementation Science* **7**, 37, doi:10.1186/1748-5908-7-37 (2012).
39 Eccles, M., Grimshaw, J., Walker, A., Johnston, M. & Pitts, N. Changing the behavior of healthcare professionals: the use of theory in promoting the uptake of research findings. *Journal of Clinical Epidemiology* **58**, 107-112, doi:https://doi.org/10.1016/j.jclinepi.2004.09.002 (2005).
40 Hakkennes, S. & Dodd, K. Guideline implementation in allied health professions: a systematic review of the literature. *Quality & safety in health care* **17**, 296-300, doi:10.1136/qshc.2007.023804 (2008).
41 Prihodova, L., Guerin, S., Tunney, C. & Kernohan, W. G. Key components of knowledge transfer and exchange in health services research: Findings from a systematic scoping review. *J Adv Nurs* **75**, 313-326, doi:10.1111/jan.13836 (2019).
42 Michie, S. *et al.* Making psychological theory useful for implementing evidence based practice: a consensus approach. *Quality and Safety in Health Care* **14**, 26, doi:10.1136/qshc.2004.011155 (2005).
43 Grol, R. Personal paper. Beliefs and evidence in changing clinical practice. *BMJ (Clinical research ed.)* **315**, 418-421, doi:10.1136/bmj.315.7105.418 (1997).

44 Lau, R. *et al.* Achieving change in primary care—causes of the evidence to practice gap: systematic reviews of reviews. *Implementation Science* **11**, 40, doi:10.1186/s13012-016-0396-4 (2016).
45 Lewis, S., Heard, R., Robinson, J., White, K. & Poulos, A. The ethical commitment of Australian radiographers: Does medical dominance create an influence? *Radiography* **14**, 90-97, doi:https://doi.org/10.1016/j.radi.2007.01.004 (2008).
46 Bairstow, P. J., Persaud, J., Mendelson, R. & Nguyen, L. Reducing inappropriate diagnostic practice through education and decision support. *International Journal for Quality in Health Care* **22**, 194-200, doi:10.1093/intqhc/mzq016 (2010).
47 Sobiecka, A., Bekiesińska-Figatowska, M., Rutkowska, M., Latos, T. & Walecki, J. Clinically Unjustified Diagnostic Imaging - a Worrisome Tendency in Today's Medical Practice. *Pol J Radiol* **81**, 325-330, doi:10.12659/PJR.896847 (2016).
48 de Lacey, G. J. *et al.* Rationalising abdominal radiography in the accident and emergency department. *Clinical radiology* **31**, 453-455, doi:10.1016/s0009-9260(80)80191-7 (1980).
49 Eisenberg, R. L., Heineken, P., Hedgcock, M. W., Federle, M. & Goldberg, H. I. Evaluation of plain abdominal radiographs in the diagnosis of abdominal pain. *Annals of surgery* **197**, 464-469, doi:10.1097/00000658-198304000-00016 (1983).
50 Stower, M. J., Amar, S. S., Mikulin, T., Kean, D. M. & Hardcastle, J. D. Evaluation of the plain abdominal X-ray in the acute abdomen. *Journal of the Royal Society of Medicine* **78**, 630-633, doi:10.1177/014107688507800806 (1985).
51 Morris-Stiff, G., Stiff, R. E. & Morris-Stiff, H. Abdominal radiograph requesting in the setting of acute abdominal pain: temporal trends and appropriateness of requesting. *Ann R Coll Surg Engl* **88**, 270-274, doi:10.1308/003588406X98586 (2006).
52 Radiologists, R. C. o. *Indications for Plain Abdominal films from the Emergency Department*, <https://www.rcr.ac.uk/audit/indications-plain-abdominal-films-emergency-department> (2016).
53 Vom, J. & Williams, I. Justification of radiographic examinations: What are the key issues? *J Med Radiat Sci* **64**, 212-219, doi:10.1002/jmrs.211 (2017).
54 García Villar, C. Radiología basada en la evidencia en el diagnóstico por imagen: ¿qué es y cómo se practica? *Radiología* **53**, 326-334, doi:https://doi.org/10.1016/j.rx.2011.02.009 (2011).
55 Higgins, R., Robinson, L. & Hogg, P. Unlocking Student Research Potential: Toward a Research Culture in Radiography Undergraduate Learning Curricular. *Journal of Medical Imaging and Radiation Sciences* **46**, S6-S9, doi:10.1016/j.jmir.2015.06.009 (2015).
56 Logan, J. & Graham, I. D. Toward a comprehensive interdisciplinary model of health care research use. *Science communication* **20**, 227-246 (1998).
57 Straus, S. E. & Sackett, D. L. Using research findings in clinical practice. *BMJ (Clinical research ed.)* **317**, 339-342, doi:10.1136/bmj.317.7154.339 (1998).
58 Smith, T. Evidence based medical imaging (EBMI). *Radiologic technology* **80**, 270-275 (2009).
59 Klaic, M., McDermott, F. & Haines, T. How soon do allied health professionals lose confidence to perform EBP activities? A cross-sectional study. *Journal of Evaluation in Clinical Practice* **25**, 603-612, doi:10.1111/jep.13001 (2019).
60 Hendry, J. Promoting compassionate care in radiography – What might be suitable pedagogy? A discussion paper. *Radiography* **25**, 269-273, doi:https://doi.org/10.1016/j.radi.2019.01.005 (2019).
61 Strudwick, R. & Harvey-Lloyd, J. Preparation for Practice through Service User involvement in the Diagnostic Radiography curriculum at University Campus Suffolk. *International Journal of Practice-based Learning in Health and Social Care* **1**, 37-46, doi:10.11120/pblh.2013.00016 (2013).